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LONGEVITY OF THE SEEDS OF CEREALS, CLOVERS, AND TIMOTHY

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This paper is the result of an investigation begun at the Seed Branch, Ottawa, in 1900. The object was to determine the longevity of some of our common crop seeds when kept under favorable and uniform storage conditions. Samples of the cereal crops of 1900, 1901, and 1902, and of the clovers and timothy of 1902 and 1903, were collected. By working with samples of all the standard varieties of the time, collected in successive years from the same farmers, in representative parts of Canada, it was believed that valuable generalizations could be drawn. Four hundred and thirty-eight samples in all were collected. Some of these proved to be too small, and were completely used up before the life of the seed was ended. A sufficient number remain, however, to allow reliable averages to be obtained.

The seeds were stored in cotton sacs or manila envelopes which were kept at ordinary room temperature in a galvanized iron chest with a lid. Once a year, in late summer, they were tested for germination. The records thus permit a comparison of their viability after various lengths of time in storage. The results of tests are recorded in the tables, to which reference will be made as each species is under consideration.

The first results were recorded in 1903, so that in the case of seeds collected in 1900 and 1901 we do not know the percentage germination for the first years. In isolated cases, results of later tests are not available as is shown by gaps in the tables. In calculating averages they have in each case been recorded to the nearest whole number.

WHEAT

Of spring wheat, forty-seven samples from the crop of 1900, sixty from that of 1901, and sixty-three from that of 1902 were collected. They represent fourteen varieties and were obtained directly from farmers and from the same stock in successive years, grown in representative localities in all the provinces of Canada.

The curve in figure 1 is drawn from the average germination of all these samples for each year of their age. Practically all the kernels retain their vitality for the first five years. Then the weaker ones begin to die, and the curve gradually becomes steeper. More than 75 percent of the seeds lose their vitality between the ages of eleven and fifteen years, and about one half of these die in their 13th year. After the 15th year, the curve begins

to flatten again. Its direction in the seventeenth year is practically parallel to that in the tenth, and in the eighteenth and nineteenth years its direction corresponds with that in the fifth and sixth years.

When an average sample of wheat is stored for a long period, this investigation shows that its depreciation is divided into three more or less distinct periods. During the first few years (ten or eleven on the average for our Canadian samples), the weak grains gradually die. After this comes the period when the seeds of average vitality (forming the bulk of the sample) die very rapidly. A few seeds, very tenacious of life, are still left, and slowly lose their vitality during the final period of about three years.

It would be interesting for some one who has proper facilities at his disposal to raise plants from the seeds of these three divisions separately, and determine whether there are separate genotypes with different powers of resistance and whether their hardiness is transmitted to the plants which they produce and to their descendants. The work of Crocker and Groves (Proceedings of the National Academy of Sciences, March, 1915) tends to show that the loss of viability is due to the coagulation of the cell proteins, and if this is so it would be unnecessary to wait for years for the seeds to die at ordinary temperatures. Their vitality could be destroyed by carefully regulated heat after the manner used by these investigators.

The results so far considered have to do with total germination percentages as determined by a ten-day test in a standard germinator at alternating temperatures of 20° C. to 30° C. Unfortunately complete records of the preliminary four-day tests, which are believed to give an indication of the energy of germination, are not available. Records of these were kept after the tenth year, however, and are recorded on the graph by means of the dotted curve, which follows a course practically parallel to that of the main curve. During the second period of depreciation the preliminary count is from 6.5 to 8 percent lower than the final count. The energy of germination of a considerable portion of the seeds which are to die during the next year has been weakened. During the third period there is a smaller absolute difference between the two results, but a greater comparative difference; *i.e.*, of the seeds left alive after the end of the second period the greater proportion have lost most of their energy of germination.

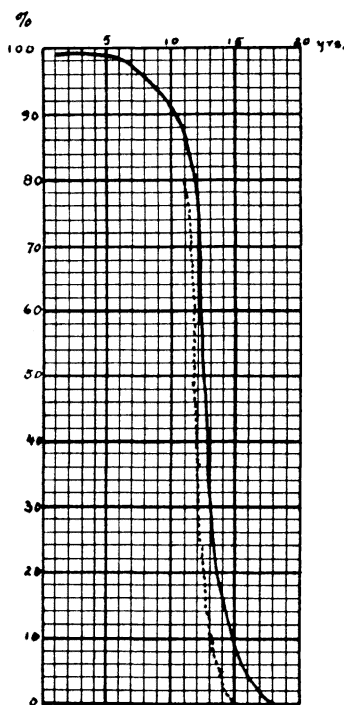


FIG. 1. Longevity curve for spring wheat.

During the first period, if records had been preserved, there is no doubt that we should have found the preliminary and final counts approximating more closely. Although Crocker and Groves, in their work mentioned above, took no account of the depreciation of the seeds after 25 percent of them had died, their results are in agreement with those here obtained. They observe that age lowers the percentage germination and increases the time required for sprouting.

Deviations from the average curve shown in figure 1 are found in some individual cases. An attempt was made to connect these with the meteorological conditions of the year and place of growth. No satisfactory results were obtained, as meteorological statistics for the exact localities where samples were gathered had not been taken.

The variations generally are of two kinds. In very strong samples the tendency is for the first period to be longer, the second shorter, and the division between them much sharper than in average cases. For example, of the Nova Scotia crop of 1902, of which eight samples were investigated (see table 1) 96 percent germinated when twelve years old. After another year only 70 percent were alive, and in three more years the germination was reduced to 9 percent—very slightly above the average for that age. In weaker samples the tendency is toward a flattening of the curve. The Prince Edward Island crop of 1900 and the Ontario crops of 1900 and 1901 are examples of this. Extreme examples are to be seen in the Northwest Territories crop of 1901 and in the Quebec crop of 1900.

No marked difference in longevity has been observed between different varieties.

OATS

One hundred and seventy-nine samples of oats were used—fifty-two from the 1900 crop, sixty-four from that of 1901, and 63 from that of 1902. They include thirty varieties.

Thir longevity is much greater than that of wheat, possibly owing to the protection of the hulls. 41 percent of the nineteen-year-old kernels are still alive. The longevity curve for the oats differs from that of wheat in two respects. The first period is longer, and the drop in the second period is not nearly so steep, *i.e.*, the kernels live longer and there are more variations in their span of life. In the year 1900, conditions seem to have been less favorable for oats than the normal conditions. The vitality of samples gathered in this year falls off much more rapidly than is the case for 1901 and 1902, and this circumstance makes the second division of the curve in figure 2 considerably steeper than it otherwise would have been. In some cases the 1900 oats start out with a high germination, but in a few years they fall below the crops of other years. Compare for example the Manitoba crops of 1900 and 1902, as recorded in table 2. During the growing season of 1900 the temperature in general was higher than in 1902 when the strongest oats were produced. Slower growth due to low temperature may

TABLE 2. Germination of oats at different ages

Province	Sam- ples Used	Year of Growth	1 Yr. Old	2 Yrs. Old	3 Yrs. Old	4 Yrs. Old	5 Yrs. Old	6 Yrs. Old	7 Yrs. Old	8 Yrs. Old	9 Yrs. Old	10 Yrs. Old	11 Yrs. Old	12 Yrs. Old	13 Yrs. Old	14 Yrs. Old	15 Yrs. Old	16 Yrs. Old	17 Yrs. Old	18 Yrs. Old	19 Yrs. Old
Nova Scotia.....	8	1900		98	97	98	98	99	97	97	97	95	96	93	94	77	69	56	42	27	27
Prince Edward Island....	8	1902	97	98	98	98	98	97	100	97	99	98	99	97	96	98	95	92	91	48	42
	9	1900		98	98	99	100	99	99	98	99	99	98	98	96	94	89	84	80	77	
	8	1901		97		99	99	99	100	98	100	99	99	98	99	99	87	89	93		
New Brunswick.....	6	1902	97	100		99	99	99	100	99	99	98	99	97	97	90	83	73	61	55	49
	8	1900		99		99	100	99	99	99	99	99	97	98	95	95	91	85	86		
	8	1902	95	99	99	99	99	99	99	95	99	99	97	96	92	92	78	64	55	48	43
Quebec.....	8	1900		93	96	97	100	97	96	97	96	94	96	92	92	83	80	64	65	64	
	8	1901		99	98	99	100	98	99	99	99	98	97	96	91	92	88	86	86		
	8	1902	97	98	98	97	97	99	98	99	99	98	98	97	95	91	85	77	59	52	50
Ontario.....	7	1900		97	97	98	98	97	97	98	98	95	96	93	86	81	80	73	62	60	
	8	1901		98	98	99	99	97	99	99	97	98	99	95	95	88	80	79	59	52	
	8	1902	97	99	99	98	97	100	98	97	98	97	97	96	96	97	92	84	79	44	42
Manitoba.....	4	1900		98	99	99	99	98	93	99	99	98	98	96	95	90	96	67	59	44	
	8	1901		97	99	99	99	99	100	99	98	98	98	98	96	93	89	81	79	78	
	7	1902	90	91	92	93	94	92	92	90	93	93	91	89	85	90	83	77	76		
Northwest Territories....	4	1900		75	76	76	80	82	80	80	80	78	78	76	74	67	57	48	37	34	35
	8	1901		93	91	91	91	89	84	80	80	80	81	72	72	58	57	50	45	50	
	8	1902	96	96	93	97	97	98	96	93	98	95	92	90	84	83	72	68	58	46	41
British Columbia.....	7	1900		95	95	97	97	97	96	96	95	95	98	90	93	86	81	64	53		
	8	1901		97	97	98	100	100	99	99	99	99	96	95	92	95	90	90	88		
	8	1902	93	97	98	98	98	97	98	96	97	96	96	93	91	88	83	74	68	53	41
Average.....	8	1902	95	97	96	97	98	98	97	96	97	99	96	95	93	92	90	90	88		

have produced hardness, or it is possible that owing to the warmer weather of 1900 more seed was produced by weak strains of plants.

The sample obtained from the Northwest Territories in 1900 germinated in very low proportions even when fresh. This is due no doubt to the fact that a cold wave passed over that part of the country in August and in most parts the temperature was several degrees below freezing at some time during the ripening period.

In the majority of cases there is a slight rise in the germination of oats during the first four or five years of storage. While it has been known for a long time that their germination improved during the winter after harvesting, I have seen no account of the continuation of this improvement beyond the first year. The rise is not found in every case. As a rule it is more pronounced in the poorer samples. There is one exception in the Northwest Territories crop for 1901, which germinated in rather low proportions after two years, and from then on showed a gradual decrease.

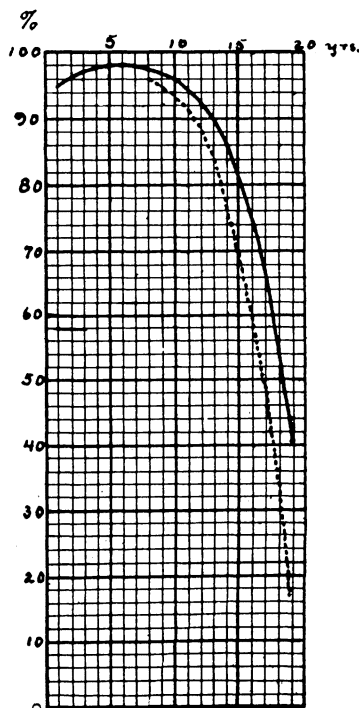


FIG. 2. Longevity curve for oats.

The difference between the final germination (in 10 days) and the preliminary count (in 4 days) increases with increasing age.

The tests were carried on at temperatures alternating between 30° C. in the daytime and 20° C. at night. Later experience has proved that these temperatures are not as satisfactory for northern grown oats as temperatures somewhat lower.

TIMOTHY

Twenty-five samples of timothy were used for the investigation. Twelve were raised in 1902 and thirteen in 1903.

The curve for these is shown in figure 3. The seed begins to depreciate in value at once, and the life of the strongest kernels is comparatively short. The three periods of depreciation are not marked off so sharply from each other as in the case of harder seeds. The germination begins to fall off rapidly after the seventh year, when it is 84 percent. By the twelfth year it is reduced to 11.5 percent, and after that the curve flattens again until at seventeen years of age the seed is practically all dead.

No records of preliminary counts were kept until the tenth year, when only 54 percent of the seed was left alive, and such as are available are therefore of little or no value.

TABLE 3. *Germination of timothy at different ages*

No. of Samples	Year of Growth	1 Yr. Old	2 Yrs. Old	3 Yrs. Old	4 Yrs. Old	5 Yrs. Old	6 Yrs. Old	7 Yrs. Old	8 Yrs. Old	9 Yrs. Old	10 Yrs. Old	11 Yrs. Old	12 Yrs. Old	13 Yrs. Old	14 Yrs. Old	15 Yrs. Old	16 Yrs. Old	17 Yrs. Old
12.....	1902	97	96	91	96	90	87	83	74	63	58	24	7	2	3	1	1	0
13.....	1903		93	94	92	90	86	85	81	72	52	23	13	14	5	3	2	
Average.....		97	94	93	94	90	86	84	77	68	54	23	10	8	4	2	1	0

TABLE 4. *Germination of alsike at different ages*

No. of Samples	Year	1 Yr. Old	2 Yrs. Old	3 Yrs. Old	4 Yrs. Old	5 Yrs. Old	6 Yrs. Old	7 Yrs. Old	8 Yrs. Old	9 Yrs. Old	10 Yrs. Old	11 Yrs. Old	12 Yrs. Old	13 Yrs. Old	14 Yrs. Old	15 Yrs. Old	16 Yrs. Old	17 Yrs. Old
12.....	1902	93	90	85	84	79	70	67	54	49	45	34	14	18	17	20	19	19
12.....	1903	93	92	91	87	81	77	72	65	63	45	25	28	29	30	24	30	
Average.....		93	91	89	85	80	73	70	60	56	45	29	20	23	24	22	24	19

TABLE 5. *Germination of red clover at different ages*

No. of Samples	Year of Growth	1 Yr. Old	2 Yrs. Old	3 Yrs. Old	4 Yrs. Old	5 Yrs. Old	6 Yrs. Old	7 Yrs. Old	8 Yrs. Old	9 Yrs. Old	10 Yrs. Old	11 Yrs. Old	12 Yrs. Old	13 Yrs. Old	14 Yrs. Old	15 Yrs. Old	16 Yrs. Old	17 Yrs. Old
12.....	1902	97	93	86	80	77	65	61	57	48	44	27	7	15	11	14	8	9
12.....	1903	96	96	92	86	75	68	68	59	59	43	17	21	29	28	16	23	
Average.....		96	94	90	83	76	66	65	58	54	44	22	14	23	18	15	17	9

ALSIKE AND RED CLOVER

Twelve samples of each of these from the 1902 crop and twelve raised in 1903 were used, and the tests were carried on at 18° to 20° C. The curves

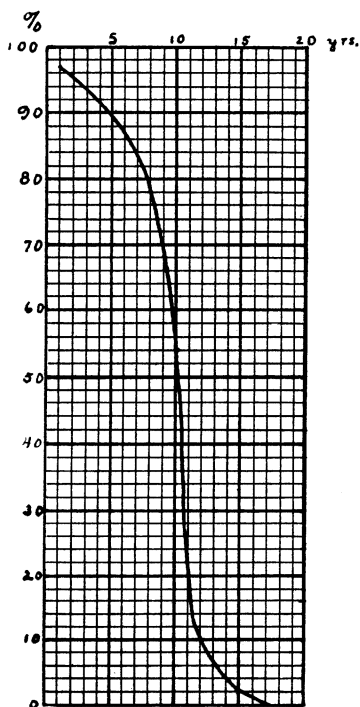


FIG. 3. Longevity curve for timothy.

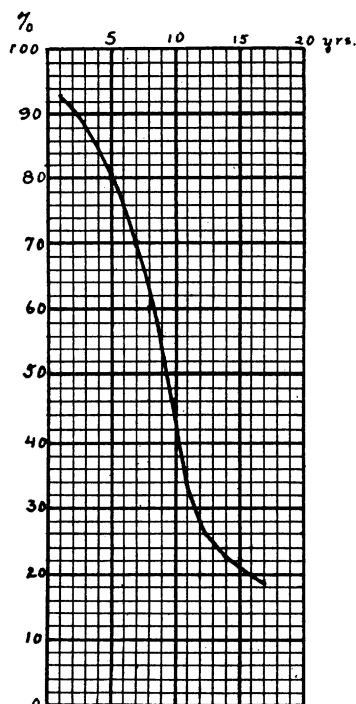


FIG. 4. Longevity curve for alsike.

are shown in figures 4 and 5. The interesting thing about them is their regular decline from the first, making each curve, as far as it has yet gone, approach a straight line much more closely than in the case of any other crop studied. Both clovers have a larger proportion of long-lived seeds (over 15 years) than wheat, but from the standpoint of a practical seedsman their longevity is not nearly so great. After eleven years, wheat on the average still germinates to the extent of more than 85 percent, but eleven-year-old alsike or red clover seed germinates less than 40 percent. (This result is calculated from the curve. The actual germination obtained in the laboratory on eleven- and twelve-year-old samples was much less, but the results of later and earlier tests make it evident that the percentages obtained in these two years were not correct.)

The natural expectation would be that the curves for the clovers would be almost horizontal at the first owing to the gradual softening of "hard seeds" with age. This, in the course of an experiment not yet ready for

publication, has been proved to be true in alfalfa. The samples contained

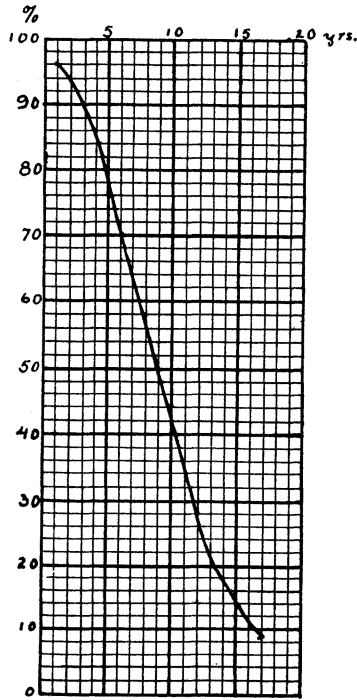


FIG. 5. Longevity curve for red clover.

a considerable proportion of "hard seeds," and for a few years the germination percentage increased as they became permeable.

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